



## RESEARCH ARTICLE

## NEONATAL BACTERIAL CONJUNCTIVITIS IN TERTIARY HOSPITALS IN SANA'A CITY, YEMEN

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### Abstract

**Background:** Ophthalmia Neonatorum (ON) is the most widespread eye infection occurring in the first 28 days of life. Although most of these cases are benign, some may progress to systemic complications or blindness if left untreated.

**Objectives:** The current study was conducted with the aim of revealing the bacteriological causes of conjunctivitis in neonates and the antibiotic sensitivity pattern of these bacteria.

**Subjects and methods:** The study included all neonates at the age of 1 to 28 days presenting at the neonatal nurseries with Neonatal Intensive Care Unit (NICU) and level II care beds in three hospitals; Authority of Al-Thawra General Hospital, Al-Kuwait University Hospital and Al-Sabeen Maternity and Child Hospital in Sana'a city, Yemen. A full history was taken from each nurse and mothers of the neonates included in the study in which the findings were recorded in a predesigned questionnaire including socio demographic, maternal clinical information and therapeutic interventions. To isolate the causative agent, the conjunctival swabs were inoculated on proper media and bacteria were identified by standard microbiological methods and antibiotic resistance was done for the isolates.

**Results:** 203 swabs were collected from newborns with eye discharge over a nine-month period. Positive growth rate was 51.7%, males were more affected (57.1%), 80% of affected neonates had low birth weight, 71.4% of preterm infants were most affected ( $p < 0.01$ ). There was a significant relationship between invasive and non-invasive mechanical ventilation with neonatal conjunctivitis ( $p < 0.05$ ). Gentamicin showed good *in vitro* sensitivity to all bacteria isolated, *Staphylococcus aureus* (83%), *Escherichia coli* 84.6%, with *P. aeruginosa* it was 60%.

**Conclusion:** The vast majority of cases of neonatal conjunctivitis were mild with a high level of occurrence; *Staphylococcus aureus* and *Klebsiella pneumoniae* were the major bacterial agents, neonatal conjunctivitis most likely to be a hospital-acquired infection. There was a significant association between phototherapy, non-invasive ventilation and incidence of neonatal conjunctivitis. Gentamicin had high activity against the bacteria isolated in this study.

**Keywords:** antibiotic sensitivity, bacteriological causes, conjunctivitis, neonates, ophthalmia neonatorum (ON), Yemen.

### INTRODUCTION

Ophthalmia neonatorum (ON) also known as neonatal ophthalmia and/or neonatal conjunctivitis is the most widespread eye infection occurring in the first 28 days of life. Although most of these cases are benign, some may progress to systemic complications or blindness if

left untreated<sup>1</sup>. Newborn conjunctiva is sterile at birth but soon becomes colonized by many microorganisms that may be either pathogenic or non-pathogenic, besides it is susceptible to infection, not only because of low levels of antibacterial agents and proteins such as lysozyme and immunoglobulins A and G, but because the lacrimal membrane and outflow are just

beginning to develop. Neonatal ophthalmia are characterized by purulent eye discharge and redness of the conjunctiva with or without swelling of the eyelid, clinical presentations of the eyes of newborns are not etiologically diagnostic; and microbiological with cytology, cultures and microbial sensitivities are mandatory for diagnoses and treatment. The choice of antimicrobial therapy is based on the findings of the laboratory<sup>2</sup>. Neonatal conjunctivitis is a global problem with incidence ranging from 0.9% to 33% in different countries. Neonatal ophthalmia is usually acquired either from the maternal reproductive system or acquired after birth from a hospital or community setting. Notwithstanding, it can be caused by chemical inflammation, bacterial infections, and viral infections, but most cases of conjunctivitis in newborns are caused by bacterial factors<sup>3</sup>. Bacterial pathogens mainly often reported as causative pathogens are *coliforms*, coagulase-negative *Staphylococci*, *pneumococci*, *enterococci*, and *Staphylococcus aureus* which tend to cause mild to moderate disease<sup>4</sup>. In addition there are viruses that cause mild conjunctivitis in neonates such as *rhinovirus*, *adenovirus* and *bocavirus*. *Neisseria gonorrhoeae*, *Pseudomonas aeruginosa*, and *Chlamydia trachomatis* are also associated with severe conjunctival infections<sup>5</sup>.

Predisposing factors, which can increase the chance of a newborn developing neonatal conjunctivitis include increased shedding of these organisms into the mother's vaginal tract during the last trimester, premature rupture of membranes, and prolonged labor. Neonatal conjunctivitis after cesarean delivery can be due to intrauterine *chlamydial* infection as a result of early rupture of membranes<sup>6</sup>. Many studies have been conducted to study the health problems of infants and children in Yemen, including infectious diseases such as tetanus, protozoa, hepatitis viruses, and even eye problems such as trachoma and corneal ulcers<sup>7-18</sup>, but there is no single study regarding Ophthalmia neonatorum prevalence, bacteriological causes, and antibiotic sensitivity pattern, in order to know the realistic recommendations for the routine prevention of the eye, which must be practiced immediately after birth, to prevent the occurrence of this dangerous infection for newborns. The current study was conducted with the aim of revealing the bacteriological causes of conjunctivitis in neonates and the antibiotic sensitivity pattern of these bacteria.

## SUBJECTS AND METHODS

**Study design:** A prospective cross-sectional study.

**Study population and study area:** The study was conducted over a period of 9 months (February, 2021-October, 2021). The study included all neonates at the age of 1 to 28 days presenting at the neonatal nurseries with Neonatal Intensive Care Unit (NICU) and level II care beds in three hospitals; Authority of Al-Thawra General Hospital, Al-Kuwait University Hospital and Al-Sabeen Maternity and Child Hospital in Sana'a city, Yemen. There were no protocols for prophylaxis to neonatorum ophthalmia in the three hospitals during the period of the study.

**Inclusion criteria:** All babies at the age of 1 to 28 days presenting with purulent, mucoid or muco-purulent discharge either in one or both eyes.

**Exclusion criteria:** Hospitalized neonates under treatment.

**Sample size calculation:** This cross-sectional study was performed on 203 neonates (112 male and 91 female) aged 28 days. The sample size was calculated according to the following: The population of neonates attended to the tertiary hospitals in Sana'a city was 45000 per year. Expected frequency of neonatal conjunctivitis as previous report (15.8%)<sup>19</sup> and acceptable margin of error equal to 5% at 95% confidence level.

**Data collection:** The complete medical history was taken from the nurses and mothers of the neonates included in the study in which the results were recorded in a pre-designed questionnaire including socio demographic, maternal, clinical information and therapeutic interventions.

**Specimen collection:** A physical examination was performed on all study population and the severity of conjunctivitis was revealed. Samples were taken by trained healthcare staff using a sterile cotton swab moistened with sterile saline. Two conjunctival swabs were taken, one for each eye, even if the infection was in only one eye. Samples were collected from the lower conjunctival vault avoiding eyelid and eyelash boundaries and inoculated directly onto pre-prepared culture plates and then transported in secure boxes to the Microbiology Laboratory of Kuwait University Hospital to be processed on the same day.

**Culturing of eye swabs:** To isolate the causative agent, conjunctival swabs were inoculated onto an appropriate medium (all culture media Sigma-Aldrich sources) and bacteria were identified by standard microbiological methods<sup>20</sup>.

Culture media included-

**Blood agar:** used for the growth of a wide range of pathogenic bacteria. It is also required for the detection and characterization of hemolytic bacteria. After inoculation, the medium was incubated aerobic at 37°C for 24-48 h.

**Chocolate agar:** This medium has been used to grow fastidious pathogens that grow best on this highly nutritious medium. After inoculation, the plates were incubated at 37°C in a candle jar (to provide 5% CO<sub>2</sub>) for 24-48 h.

**MacConkey agar:** It is a selective and differentiating agar that only grows Gram-negative bacterial species; can differentiate Gram-negative organisms based on lactose metabolism. The plates were inoculated with the sample and then aerobically incubated at 37°C for 24 h. Then the inoculated plates were labeled on the agar side with the patient's name and date of receipt. All agar plates were inoculated by slight streaks of cotton swabs onto the agar surface in rows. Growth on the streaks was considered significant, while growth outside the streaks is likely due to contamination.

**Identification of bacteria:** Bacteria were identified by standard microbiological methods: culture traits of pure colonies, Gram staining, enzyme production, biochemical tests, and *Enterobacteriaceae* were

identified by KB003 TM Hi25 *Enterobacteriaceae* Identification Kit (Hi Media Laboratories, India).

**Antibiotic susceptibility testing:** Antibiotic resistance was done using Kirby-Bauer disc diffusion methods and interpretation of antibiotic sensitivity results was done according to CLSI<sup>21</sup>. Antibiotic disks and media powders used in NCPHL are usually Sigma-Aldrich sources. GPB and GNB isolates consisting of *P. aeruginosa* (ATCC 27853) *Escherichia coli* (ATCC 25922), and *S. aureus* subsp *Aureus* ATCC 25923 was used as quality control for a routine DDM test recommended in the NCPHL Department of Microbiology.

#### Ethical approval

Written consent was obtained in all parent cases. Ethical approval was obtained from the Medical Research and Ethics Committee of the Faculty of Medicine and Health Sciences, Sana'a University with reference number (2221).

## RESULTS

Of the newborns with eye discharge, 203 swabs were collected over a nine-month period. The general characteristics of all neonates in this study are shown in Table 1.

**Table 1: General characteristics of the study population.**

Variable	Frequency (%)
<b>Gender</b>	
Male	112(55.2)
Female	91(44.8)
<b>Weight</b>	
Normal weight	141(69.5)
LBW	62(30.5)
<b>Gestational category</b>	
Preterm	88(43.4)
Term	115(56.7)
Post-term	0(0)
<b>Onset of conjunctivitis</b>	
First week	112(55.2)
Second week	55(27.1)
Third week	21(10.3)
Fourth week	15(7.4)
<b>Mode of delivery</b>	
Spontaneous Vaginal delivery	140(69)
Cesarean section	63(31)
<b>Mechanical Ventilation</b>	
Invasive	48(23.6)
Noninvasive	37(18.2)
Without	118(58.1)
<b>Neonatal phototherapy (NNPT)</b>	
Yes	117(57.6)
No	
<b>Antimony (Kohl) applied</b>	
Yes	136(67)
No	67(33)
<b>Eye involvement</b>	
Unilateral	86(42.4)
Bilateral	117(57.6)

Table 2 shows that the most common bacteria concerned in ophthalmia neonatorum in order of reducing frequency were *S. aureus*, *Klebsiella pneumoniae*, *E. coli* and *P. aeruginosa*.

**Table 2: The Frequency of isolated bacteria causing neonatal conjunctivitis.**

Bacteria	Number of isolates (%)
<i>S. aureus</i>	59(56.2)
<i>K. species</i>	30(28.6)
<i>E. coli</i>	13(12.4)
<i>P. aeruginosa</i>	3(2.9)
Total	105(100)

Table 3 shows that among 105 samples (51.7%) yielded growth and no growth was detected in 98 samples (48.3%), among this males were 60(57.1%) and the females were 45 (42.9%). Difference between the proportions of infected males to females infected was not statistically significant ( $p=0.56$ ). Eighty percent of affected neonates were low birth weight (the mean±SD weight of the neonates was 2.6±0.5 kg). Out of the total number of 105 bacterial conjunctival neonates, 30 (28.6%) babies were term (gestational age greater than 37 completed weeks), and 75(71.4%) were preterm (gestational age <37 weeks). None of the babies was post-term (gestational age greater than 42 weeks). Most of the affected neonates were premature ( $p<0.01$ ). The mean age of onset was 8.8±6.7 days. Most cases of neonatal conjunctivitis 78(74.3%) occurred in the first week of life while 21 (20%) presented within the second week of life. The rest of cases 5(4.8%) and 1(0.95%) developed in the third and the fourth week of life, respectively. Bilateral conjunctivitis was present in 117(57.6%) of all neonates, while unilateral involvement was seen in 86 (42.4%) of the patients. Table 4 shows that among 105 neonates with conjunctivitis 70 (66.7%) neonates were delivered vaginally and 35(33.3%) were delivered by cesarean section. There was no relation between the delivery mode with neonatal bacterial conjunctivitis ( $p = 0.46$ ). A positive history of prolonged rupture of fetal membranes (>18 hours) was documented in 9(8.6%) neonates with conjunctivitis, however, it was not statistically significant ( $p=0.69$ ). Moreover, no relation between the history of maternal infections of lower genital tract with neonatal bacterial conjunctivitis ( $p=0.099$ ). There was a statistically significant between invasive and non-invasive mechanical ventilation with neonatal conjunctivitis ( $p<0.05$ ) (Table 5). Among 105 neonatal conjunctivitis cases, 3 cases (2.9%) needed invasive mechanical ventilation and 26 cases (24.8%) needed noninvasive mechanical ventilation mainly nCPAP (nasal continuous positive airway pressure) during their stay in neonatal intensive care units (NICU). There was a statistically significant association between Neonatal phototherapy (NNPT) and conjunctivitis ( $p<0.01$ ). Neonates who experienced phototherapy presented an occurrence rate of conjunctivitis of 59(56.2%) markedly higher than amongst those not including phototherapy criteria 46(43.8%).

**Table 3: Demographic data and clinical manifestations among neonates with bacterial conjunctivitis (n=105).**

Variable	Bacterial conjunctival neonates=105	Non-bacterial conjunctival neonates=98	OR (>1)	CI (95%)	X <sup>2</sup> (≥ 3.7)	p-value (p< 0.05)
<b>Gender</b>						
Male	60 (57.1%)	52 (53.1%)	1.2	0.7-1.2	0.34	0.559
Female	45(42.9%)	46 (46.9%)				
<b>Weight</b>						
LBW	84(80.0%)	57(58.2%)	2.9	1.5-5.4	11.3	0.001
Normal weight	21(20.0%)	41(41.8%)				
<b>Gestational period</b>						
Preterm	75 (71.4)	13 (13.3%)	0.1	0.03-0.13	69.8	< 0.01
Term	30 (28.6)	85(86.7%)				
<b>Onset of conjunctivitis</b>						
First week	78(74.3%)	34(34.7%)	2.7	1-7.4	4.1	0.041
Second week	21(20.0%)	34(34.7%)				
Third week	5(4.8%)	16(16.3%)				
Fourth week	1(1.0%)	14(14.3%)				
<b>Eye involvement</b>						
Unilateral	45(42.9%)	41(41.8%)	1.04	0.6-1.9	0.02	0.883
Bilateral	60(57.1%)	57(58.2%)				

OR: Odd ratio; CI: Confidence Intervals; X<sup>2</sup>: Chi square; p: Probability value

There was not a statistically significant association between application of Alkohl and the occurrence of conjunctivitis ( $p=0.845$ ). Among 105 neonatal conjunctivitis, 71(67.6%) cases were applied Alkohl and 34(32.4%) were not applied Alkohl. Table 6 shows that gentamycin showed a good sensitivity *in vitro* to all isolated bacteria. *S. aureus* was found to be sensitive to gentamycin (83%), followed by Chloramphenicol (77.9%), ofloxacin (64.4%),

erythromycin (55.9%) and tetracycline (45.2%). *K. pneumoniae* was resistant to erythromycin and sensitive to gentamycin, ofloxacin, tetracycline and chloramphenicol as following: 56.6%, 43.3%, 40% and 33.3%, respectively. *E. coli* showed sensitivity to gentamycin, ofloxacin and chloramphenicol (84.6%, 46.1%, 40% and 38.4%, respectively). *P. aeruginosa* showed sensitivity only to gentamycin (60%) and ofloxacin (30%).

**Table 4: The maternal risk factors in correlation with ophthalmia neonatorum.**

Parameter	Bacterial conjunctival neonates n=105	Non-bacterial conjunctival neonates n=98	OR (>1)	CI (95%)	X <sup>2</sup> (≥ 3.7)	p-value (p< 0.05)
<b>Mode of delivery</b>						
Vaginal delivery	70(66.7%)	70(71.4%)				
Cesarean section	35(33.3%)	28(28.6%)	0.8	0.44-1.4	0.54	0.46
<b>PROM*</b>						
Present	9(8.6%)	10(10.2%)	0.82	0.32-2.1	0.16	0.69
Absent	96(91.4%)	88(89.8%)				
<b>History of maternal infections of the lower genital tract</b>						
Infected	50(47.6%)	58(59.2%)				
Non-infected	55(52.4%)	40(40.8%)	0.63	0.36-1.1	2.7	0.099

OR: Odd ratio; CI: Confidence Intervals; X<sup>2</sup>: Chi square; p: Probability value, PROM: Prolonged rupture of membranes.

## DISCUSSION

The current study showed that bacteria cultures were positive in 51.7% of the neonates and 48.3% of the neonates were free of demonstrable pathogenic bacteria despite the presence of conjunctivitis. Similar prevalence rates were reported from Saudi Arabia (60%)<sup>22</sup> and Iraq (69%)<sup>23</sup>. On the other hand, higher prevalence rates (81.5% and 80.5%, from United Arab Emirate and Iran, respectively were reported<sup>24, 25</sup>. This wide variation may be attributed to differences in the geographic distribution of pathogens and standards of obstetric and perinatal care. The current results showed that 98 samples (48.3%) did not reveal any growth that might be due to other organisms that had not been

researched such as *Candida albicans* or viruses. This negative percentage is higher than Saudi Arabia (40%) and Iraq (31%)<sup>22,23</sup>. The present study shows a high percentage of *S. aureus* as the most common causative agent (56.2%) followed by *K. pneumoniae* (28.6%), *E. coli* (12.4%) and less commonly by *P. aeruginosa* (2.9%). Similarly, several studies reported that *S. aureus* is the main bacterial cause of neonatal conjunctivitis from different parts of the world, including the United Arab Emirates, Iran (53.9%), Nigeria (57.1%) and Pakistan (65%)<sup>24-27</sup>. In contrast, *Enterobacter cloacae* (26.32%), *K. pneumoniae* (25.36%) and *E. coli* (35%) were the primary isolates from Saudi Arabia, Iraq and India, respectively<sup>22,23,28</sup>.

**Table 5: Clinical intervention and Alkohl application as risk factors among newborns with bacterial conjunctivitis (n=105).**

Parameter	Bacterial conjunctival neonates=105	Non-bacterial conjunctival neonates=98	OR	95% CI	X <sup>2</sup>	p-value
<b>Mechanical</b>						
<b>Ventilation</b>	3(2.9%)	45(45.9%)				
Invasive	26(24.8%)	11(11.2%)	0.04	0.01-0.12	52	< 0.01
Noninvasive	76(72.3%)	42(42.9%)	2.6	1.2- 5.6	6.2	0.013
None						
<b>NNPT</b>						
Exposed	59(56.2%)	27(27.6%)	3.4	1.9-6.1	17	< 0.01
Non-exposed	46(43.8%)	71(72.4%)				
<b>Alkohl (antimony)</b>						
Applied		65(66.3%)	1.0	0.59-1.9	0.038	0.845
Not applied	71(67.6%)	33(33.7%)				
	34(32.4%)					

OR (Odd ratio) >1 (at risk); X<sup>2</sup> (Chi square) ≥ 3.7; CI: Confidence Intervals; p (Probability value) < 0.05 (significant); NNPT: Neonatal phototherapy

The role of *S. aureus* in neonatal conjunctivitis is controversial because it is often isolated from the eyes of asymptomatic neonates<sup>29</sup>. However, in our study only newborns with signs and symptoms of conjunctivitis were evaluated. Although prophylaxis for neonatal *Neisseria gonorrhoea* and *C. trachomatis* was not used in these three hospitals; *N. gonorrhoeae* and *C. trachomatis*, which are usually causes of ophthalmia neonatorum, have not been diagnosed. A similar finding of zero or minimal cases of *gonococcus* and *chlamydial* conjunctivitis has been reported elsewhere<sup>26,27</sup>.

The findings may indicate a rare occurrence of *gonorrhoea* and *chlamydia* in the community. In the current results, 57.1% of ON patients were males and 42.9% were females, this is similar to that reported from Iran, Nigeria and Saudi Arabia with slightly increased in male patients (54.4%),<sup>25</sup> (66.3%)<sup>26</sup> and (51%)<sup>22</sup>. It was also observed in the present results that the majority of positive cases of bacterial cultures occurred between the lowest birth weight (80%) and premature neonates (71.4%), because these groups of neonates are more at risk as confirmed by the results of Dias *et al*<sup>30</sup>.

**Table 6: Antibiotics susceptibility to isolated bacteria.**

Antibiotic	<i>S. aureus</i> Sensitivity(%)	<i>K. pneumoniae</i> Sensitivity (%)	<i>E. coli</i> Sensitivity (%)	<i>P. aeruginosa</i> Sensitivity (%)
Chloramphenicol	46 (77.9 %)	10(33.3%)	5(38.4%)	-
Erythromycin	33 (55.9%)	-	-	-
Gentamycin	49 (83%)	17(56.6%)	11(84.6%)	2(60%)
Ofloxacin	38 (64.4%)	13(43.3%)	6(46.1%)	1(30%)
Tetracycline	32 (54.2%)	12(40%)	-	-

This study showed a statistical significance between gestational period and the occurrence of conjunctivitis ( $p < 0.01$ ). Neonates with a positive bacterial culture were 71.4% preterm vs. 28.6% full-term. The finding is in agreement with a study by Dias *et al.*, in Portugal<sup>30</sup>. This can be attributed to the fact that conjunctivitis may develop more frequently in premature babies where they spend a long time with their eyes closed or covered, allowing bacteria to multiply, and due to the immature lacrimal system. A functional lacrimal system produces tear components, opening and closing of the eyelids act as a pump to assist tear spreading across the surface of the eye and the lacrimal ducts proceed as a drainage system, which transports away tears with epithelial debris and bacteria<sup>31</sup>. It was also noted in the current study that the vast majority of 78 cases (74.3%) occurred during the end of the first week of life. The finding is in agreement with studies from Nigeria and Iran where the majority of cases occurred within the first week of life and between 1 and 12 days of age, respectively<sup>25,26</sup>. The result indicates that the first week of life is the most susceptible period for conjunctivitis in infants. Also, the mean age of onset in

the current study is 8.8 days indicating that ON is postnatally acquired. The results of the current study showed that there was no statistical significance between ON and the conjunctivitis whether it is unilateral or bilateral ( $p = 0.883$ ). Bilateral conjunctivitis was present in 57.1% of patients, and unilateral involvement was seen in 42.9% of the patients. The result is similar to that reported by Afjeiee *et al*<sup>25</sup>.

In current study, many risk factors for bacterial neonatal conjunctivitis were evaluated. Some of them are maternal risk factors and the others related to the medical intervention during the stay at hospitals either in NICU or in the nurseries. It was found that there was no statistical significance between bacterial conjunctivitis and the maternal risk factors like the mode of delivery, PROM and the history of vaginal discharge ( $p > 0.005$ ). These results are similar to results from India, Iran and Pakistan<sup>25,27,28</sup>. This result might be due to the fact that the conjunctivitis is acquired as a result during the therapy from the hospitals contamination.

In regarding to other risk factors which result from clinical intervention, we found that there was statistical

significance in applying the invasive or noninvasive mechanical ventilation ( $p < 0.05$ ). This result is similar to that reported by Borer *et al.*,<sup>32</sup> and Dias *et al.*,<sup>30</sup> in which ventilation was a risk factor. The association between ON and respiratory support including nCPAP and invasive mechanical ventilation was interpreted as infants needing ventilator assistance may allow respiratory secretions to be transferred from the nasopharynx to the eyes, particularly during suctioning<sup>31</sup>. Another interpretation is that the mechanical ventilation such as nCPAP usually requires more manipulations and operating with hands that lead to contamination with skin normal or potential pathogenic bacteria to the ventilation<sup>31</sup>. There was statistical significance between applying of neonatal phototherapy and the occurrence of bacterial conjunctivitis ( $p < 0.01$ ). This result is similar to the results reported by Faulhaber *et al.*,<sup>33</sup> and Bayatmohktari *et al.*,<sup>34</sup>. This association is attributed to the using the eye protection devices during applying of the phototherapy<sup>35</sup>. The eye shield reduces the blinking which has protective effects from bacterial colonization in the conjunctival sac and lead to conjunctivitis<sup>34</sup>. In current study, there was no statistical significance in application of antimony ( $p = 0.845$ ). Pure kohl contains antimony sulfide and trisulfide as its main constituents. It is a traditional eyeliner and is taken from dark stone known in Arabic as "ithmed" stone<sup>36</sup>. Al-kohl is used in our community to darken the eyelids and serve as cosmetics. This result comes in agreement with a study conducted in Nigeria by Isa *et al.*<sup>37</sup>.

The sensitivity patterns in this study revealed that the highest sensitivity of *S. aureus* was to gentamicin 83% which is similar to the result reported by Dias *et al.*<sup>30</sup>. In contrast, in another study in Iraq, *S. aureus* was more sensitive to ciprofloxacin followed by chloramphenicol<sup>23</sup>. *K. pneumoniae* in this study had an average sensitivity of gentamicin 56.6%, while, in another study in Nigeria, *K. pneumoniae* was resistant to gentamicin but sensitive to ceftazidime<sup>26</sup>. *E. coli*, which showed a high sensitivity to gentamicin (84.6%) and moderate sensitivity of *P. aeruginosa* to gentamicin (60%).

## CONCLUSIONS AND RECOMMENDATIONS

The vast majority of cases of neonatal conjunctivitis were mild with a high level of occurrence, *S. aureus* and *K. pneumoniae* were the major bacterial agents, neonatal conjunctivitis most likely to be a hospital-acquired infection. There was no statistically significant association between maternal risk factors (pre labor rupture of membranes, presence of vaginal discharge and mode of delivery) and neonatal conjunctivitis, but there was a significant association between phototherapy, non-invasive ventilation and incidence of neonatal conjunctivitis. Gentamicin had high activity against the bacteria isolated in this study. Microbiological examinations are needed prior to treatment for cases of neonatal conjunctivitis, routine eye prophylaxis as soon as possible after delivery, regardless of whether it was delivered vaginally or by caesarean section, and health workers in neonatal units

should pay attention to infection control practices in order to reduce the level of pollution.

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## AUTHOR'S CONTRIBUTIONS

The first author is a master's student who did the field and lab work and wrote the thesis. **Al-Arosi SAH:** writing original draft, literature survey. **Al-shamahi EY:** methodology, conceptualization. **Al-Kholani AIM:** formal analysis, review. **Al-Jawfi AY:** investigation, data interpretation. **Al-Shamahy HA:** critical review, supervision. **Al-Moyed KAA:** data curation, investigation. **Al-Ankoshy AAM:** data curation, investigation. All authors revised the article and approved the final version.

## DATA AVAILABILITY

The data supporting the findings of this study are not currently available in a public repository but can be made available upon request to the corresponding author.

## CONFLICT OF INTEREST

No conflict of interest associated with this work.

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